2014 FSBPA Annual Conference

Effectiveness of Beach Nourishment in Response to Sea Level Rise

Navarre Beach
Santa Rosa County
July 18, 2005

Lovers Key
Lee County
April 23, 2012

South County
St. Lucie County
November 30, 2012

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September 24, 2014
Effectiveness of Beach Nourishment in Response to Sea Level Rise

Presentation

Outline

• Beach Management Objectives

• Sea Level Rise in Florida - *historical & projected*

• Effectiveness of Alternatives – *relative to Objectives*
  • Beach Fill
  • Managed Retreat
  • Coastal Armoring – Seawalls

• Conclusions
Classic Beach Management Objectives

• Protection - of upland property & infrastructure
  (storm-damage reduction)

• Preserve Land

• Enhance Recreational Beach
  (via creation, restoration, &/or expansion)

• Habitat Restoration
  (turtle nesting, shorebirds, &/or beach mice)

Reference: USACE National Economic Development Manuals
Chapter 161 - Florida Statutes
<table>
<thead>
<tr>
<th>Location</th>
<th>Period</th>
<th>MSL Trend (mm/yr)</th>
<th>MSL Trend (in/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fernandina Beach</td>
<td>1897 - 2006</td>
<td>2.02</td>
<td>0.08</td>
</tr>
<tr>
<td>Mayport</td>
<td>1928 - 2006</td>
<td>2.40</td>
<td>0.09</td>
</tr>
<tr>
<td>Daytona Beach Shores</td>
<td>1925 - 1983</td>
<td>2.32</td>
<td>0.09</td>
</tr>
<tr>
<td>Miami Beach</td>
<td>1931 - 1981</td>
<td>2.39</td>
<td>0.09</td>
</tr>
<tr>
<td>Vaca Key</td>
<td>1971 - 2006</td>
<td>2.78</td>
<td>0.11</td>
</tr>
<tr>
<td>Key West</td>
<td>1913 - 2006</td>
<td>2.24</td>
<td>0.09</td>
</tr>
<tr>
<td>Naples</td>
<td>1965 - 2006</td>
<td>2.02</td>
<td>0.08</td>
</tr>
<tr>
<td>Fort Meyers</td>
<td>1965 - 2006</td>
<td>2.40</td>
<td>0.09</td>
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<tr>
<td>St. Petersburg</td>
<td>1947 - 2006</td>
<td>2.36</td>
<td>0.09</td>
</tr>
<tr>
<td>Clearwater Beach</td>
<td>1973 - 2006</td>
<td>2.43</td>
<td>0.10</td>
</tr>
<tr>
<td>Cedar Key</td>
<td>1914 - 2006</td>
<td>1.80</td>
<td>0.07</td>
</tr>
<tr>
<td>Apalachicola</td>
<td>1967 - 2006</td>
<td>1.38</td>
<td>0.05</td>
</tr>
<tr>
<td>Panama City</td>
<td>1973 - 2006</td>
<td>0.75</td>
<td>0.03</td>
</tr>
<tr>
<td>Pensacola</td>
<td>1923 - 2006</td>
<td>2.10</td>
<td>0.08</td>
</tr>
<tr>
<td><strong>Average:</strong></td>
<td></td>
<td><strong>2.10</strong></td>
<td><strong>0.08</strong></td>
</tr>
</tbody>
</table>
Effectiveness of Beach Nourishment in Response to Sea Level Rise

Florida

Projected Sea Level Change - 2065

State-wide
Lowest to Highest Range
per USACE

Overall: 0.24 feet to 2.91 feet

Adapted from: USACE Sea-Level Change Curve Calculator
https://corpsclimate.us/ccaceslcurves.cfm
Effectiveness of Beach Nourishment in Response to Sea Level Rise

Florida

Projected Sea Level Change

Florida: All Gauges Average

Sea Level Rise (ft above 2014 MSL)

Adapted from: USACE Sea-Level Change Curve Calculator
https://corpsclimate.us/ccaceslcurves.cfm
Alternatives

- Beach Fill
- Managed Retreat $\equiv$ “No Action” to abate erosion
- Coastal Armoring – Seawalls
Effect on Beach Fills – future nourishment to offset longshore sediment transport gradient & sea level rise

\[
\frac{\partial V}{\partial t} = (h_* + B) \frac{\partial R_0}{\partial t} + W_* \left( \frac{\partial S}{\partial t} - \frac{\partial S_0}{\partial t} \right)
\]

Where

- \( \frac{\partial V}{\partial t} \) = Volumetric rate of nourishment addition per unit length of beach (cyds. / ft. / yr.)
- \( \frac{\partial R_0}{\partial t} \) = Existing background erosion rate (ft. / yr.)
- \( \frac{\partial S}{\partial t} \) = Rate of sea level rise (ft. / yr.)
- \( \frac{\partial S_0}{\partial t} \) = Existing sea level rise rate (ft. / yr.)
- \( W_* \) = Width of the active beach profile (ft.)
- \( h_* \) = Depth of closure (ft.)
- \( B \) = Berm height (ft.)

Managed Retreat ≡ “No Action”

- Allows the shoreline to migrate landward unimpeded.
- Buildings & infrastructure either demolished or relocated.

Assumes

1. Profile shape does not change with respect to the water line.
2. The sand volume in the profile must be conserved.

\[ \Delta y = -R = -S \frac{W_*}{(h_* + B)} \]

Where

- \( \Delta y = -R \) = Horizontal shoreline recession
- \( S \) = Sea level rise
- \( W_* \) = Width of the active beach profile
- \( h_* \) = Depth of closure
- \( B \) = Berm height

Sea Level Rise

Shoreline Recession: Dean Equilibrium Profile

Assumes
1. Beach shaped to equilibrium by steady state sea conditions
2. Erosion 2-dimensional mass balance of accretion & erosion
3. Profile shape given by

\[ h = Ax^m \]

Where
- \( h \) = stillwater depth above the equilibrated profile
- \( x \) = the horizontal distance from the shoreline
- \( m \) = exponent to fit
- \( A \) = Dimensional scale parameter related to sediment

Effectiveness of Beach Nourishment in Response to Sea Level Rise

Navarre Beach
Santa Rosa County

Pensacola
Apalachicola
Cedar Key
St. Petersburg
Fort Myers
Naples
Key West
Fernandina Beach
Maysport
Daytona Beach Shores
Miami Beach
Navarre Beach
Santa Rosa County
July 18, 2005
Navarre Beach
Santa Rosa County

Initial Construction:
2.95 Mcy
4.1 miles
136 cyds/ft
2006
Navarre Beach
Santa Rosa County

Effectiveness of Beach Nourishment in Response to Sea Level Rise

Photo From: Google Earth
Effectiveness of Beach Nourishment in Response to Sea Level Rise

Navarre Beach - Santa Rosa County
Santa Rosa County
Navarre Beach
Effectiveness of Beach Nourishment in Response to Sea Level Rise

Navarre Beach - Santa Rosa County

*Nourishment* - future needs based on 8 year cycle to offset longshore sediment transport gradient & sea level rise

- **2006 Fill Density = 136 cyds/ft** for 8-year cycle
- **2015 Fill Density = 73 cyds/ft** for 8-year cycle

**Renourishment Volume (cyds/ft)**

- 2020: 41.09
- 2030: 41.53
- 2040: 42.41
- 2050: 42.86
- 2060: 42.86
- 2070: 43.74
- 2080: 44.18
- 2090: 44.62
- 2100: 45.50

**USACE Int.**

- 2020: 46.4
- 2030: 48.6
- 2040: 50.8
- 2050: 53.0
- 2060: 54.8
- 2070: 57.0
- 2080: 59.2
- 2090: 61.4
- 2100: 63.2

**USACE High**

- 2020: 65.4
- 2030: 65.4
- 2040: 65.4
- 2050: 65.4
- 2060: 65.4
- 2070: 65.4
- 2080: 65.4
- 2090: 65.4
- 2100: 65.4
Navarre Beach - Santa Rosa County

No Action - Intermediate Sea Level Change - 2065

Effectiveness of Beach Nourishment in Response to Sea Level Rise
Navarre Beach - Santa Rosa County

No Action - High Sea Level Change - 2065

Effectiveness of Beach Nourishment in Response to Sea Level Rise

- Equilibrium Profile
- Zero
- High
- Bruun
- Dean
Navarre Beach - Santa Rosa County

Seawall – by 2065

Seawall at 30 ft. seaward of house

Effectiveness of Beach Nourishment in Response to Sea Level Rise
Lovers Key - Lee County

Effectiveness of Beach Nourishment in Response to Sea Level Rise

We are here!
Lovers Key
Lee County
April 23, 2012
Effectiveness of Beach Nourishment in Response to Sea Level Rise

Lovers Key
Lee County

Initial Construction:
533,385 cy
1.1 miles
90cy/ft
2004
Lovers Key - Lee County
Effectiveness of Beach Nourishment in Response to Sea Level Rise

Lovers Key
Lee County
Effectiveness of Beach Nourishment in Response to Sea Level Rise

Lovers Key
Lee County

R-219
Lovers Key - Lee County

Nourishment - future needs based on 8 year cycle
to offset longshore sediment transport gradient & sea level rise

2004 Average Fill Density = 90.0 cyds/ft for 8 year cycle
2014 Average Fill Density = 58.1 cyds/ft for 8 year cycle

Renourishment Volume (cyds/ft)

USACE Int.  USACE High
Lovers Key - Lee County

No Action - Intermediate Sea Level Change - 2065

Effectiveness of Beach Nourishment in Response to Sea Level Rise

Equilibrium Profile  Zero  Int  Bruun  Dean

Height above MSL (ft)

Distance from MSL (ft)

R-219

34'

75'

-200  -100  0  100

-8.00  -6.00  -4.00  -2.00  0.00  2.00  4.00  6.00  8.00
Lovers Key - Lee County

No Action – High Sea Level Change - 2065

Effectiveness of Beach Nourishment in Response to Sea Level Rise
Lovers Key - Lee County

Seawall – by 2065

Seawall at 30 feet seaward of tram house
Effectiveness of Beach Nourishment in Response to Sea Level Rise

South County

St. Lucie County
South County
St. Lucie County
November 30, 2012
Effectiveness of Beach Nourishment in Response to Sea Level Rise

South County
St. Lucie County

Initial Construction:
682,500 cy
3.4 miles
38.5cy/ft
2013
Effectiveness of Beach Nourishment in Response to Sea Level Rise

South County - St. Lucie County

Normandy Beach Park

R-101

Construction Toe of Fill

PROPOSED PIPELINE CORRIDOR

Dollman Beach Park

Enhancing Coastal Life.
Effectiveness of Beach Nourishment in Response to Sea Level Rise

South County - St. Lucie County
South County - St. Lucie County
South County - St. Lucie County

Nourishment - future needs based on 10 year cycle
to offset longshore sediment transport gradient & sea level rise

2013 Fill Density = 38.5 cyds/ft for 10-year cycle
Effectiveness of Beach Nourishment in Response to Sea Level Rise

**South County - St. Lucie County**

*No Action* - Intermediate Sea Level Change - 2065

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**Equilibrium Profile**

**Zero**

**Int**

**Bruun**

**Dean**

---

**Height above MSL (ft)**

---

**Distance from MSL (ft)**

---

R-101

---

40

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COASTAL TECH

Enhancing Coastal Life.
South County - St. Lucie County

No Action – High Sea Level Change - 2065

Effectiveness of Beach Nourishment in Response to Sea Level Rise

Equilibrium Profile - Zero - High - Bruun - Dean
**South County** - St. Lucie County

*Seawall – by 2065*

- Seawall at 30 feet seaward of house
- Effectiveness of Beach Nourishment in Response to Sea Level Rise

**Graph Details:**
- **Height above MSL (ft):** -10.00 to 20.00
- **Distance from MSL (ft):** -250.00 to 100.00
- **Lines:**
  - Zero
  - Int
  - High
  - Equilibrium Profile
  - USACE Int.
  - USACE High

**Note:**
- South County and St. Lucie County refer to geographic regions.
- The graph illustrates the impact of sea level rise on coastal properties, showing various profiles assuming different climate scenarios.
- The seawall is positioned to safeguard against potential flooding issues.

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**Coastal Tech**

Enhancing Coastal Life.
Effectiveness of Beach Nourishment in Response to Sea Level Rise

**Summary**

<table>
<thead>
<tr>
<th>Shoreline Recession (feet / year)</th>
<th>Navarre Beach SRC&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Lovers Key Lee&lt;sup&gt;2&lt;/sup&gt;</th>
<th>South County SLC&lt;sup&gt;3&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int.</td>
<td>High</td>
<td>Int.</td>
<td>High</td>
</tr>
<tr>
<td>Bruun</td>
<td>0.81</td>
<td>1.49</td>
<td>0.72</td>
</tr>
<tr>
<td>2.24</td>
<td>3.97</td>
<td>1.91</td>
<td></td>
</tr>
<tr>
<td>Dean</td>
<td>2.45</td>
<td>0.67</td>
<td>1.70</td>
</tr>
<tr>
<td>5.35</td>
<td>1.94</td>
<td>3.65</td>
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<tr>
<td>Historic</td>
<td>1.0</td>
<td>4.4</td>
<td>0.56</td>
</tr>
</tbody>
</table>

1: Historic based on 1970 – 2008 surveys  
2: Historic based on 1972 – 2008 surveys  
3: Historic based on 1972 – 2006 surveys

## Summary

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Protection</th>
<th>Preserve Land</th>
<th>Recreational Beach</th>
<th>Habitat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beach Fill</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>limited by Design</td>
<td>MHWL fluctuates</td>
<td>beach width fluctuates</td>
<td>habitat fluctuates</td>
</tr>
<tr>
<td>Retreat</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Somewhat</td>
</tr>
<tr>
<td></td>
<td>&quot;demolished/ relocated&quot;</td>
<td>MHWL recedes</td>
<td>width same &amp; migrates</td>
<td>loss of upland habitat</td>
</tr>
<tr>
<td>Seawall</td>
<td>Yes</td>
<td>Somewhat</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>limited by Design</td>
<td>landward of seawall</td>
<td>beach width diminishes</td>
<td>loss of beach habitat</td>
</tr>
</tbody>
</table>
Conclusions

- Sea level change is estimated to rise 0.36 feet to 2.84 feet in Florida over the next 50 years.

- Over the next 50 years, fill quantities needed to offset sea level rise are within range of historical values.

- Beach nourishment is the only viable alternative to meet *classic* Beach Management Objectives.

- A better understanding of the effects of sea level rise upon beach nourishment is warranted.
Thank you

Questions?